Valley habitats used by listed species with other federal, state, and local programs (e.g., the SB 1086 Program, the Anadromous Fish Restoration Program, U.S. Fish and Wildlife Service recovery plans, and the Corps' Sacramento and San Joaquin River Basins Comprehensive Study) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.

- To the extent practicable, design dikes constructed in enhanced and restored saline emergent wetlands to provide optimal wetland to upland transitional habitat.
- To the extent consistent with CALFED objectives, direct ERP actions towards setting back levees in the south Delta to increase shallow water habitat.
- To the extent practicable, design setback levees in the restored Stone Lakes/Cosumnes River/White Slough habitat corridor to include a mosaic of habitats.
- Identify opportunities for implementing levee maintenance practices in the Delta that will maintain suitable levee habitat or minimize the impacts of necessary maintenance on the giant garter snake and its habitat.
- Incorporate sufficient edge habitat to support Delta mudwort in levee set back and channel island habitat restoration designs.
- Protect the Sacramento and San Joaquin river and tributary channels from physical disturbance (e.g., sand and gravel mining, dredging, and levee or bank protection and maintenance) and flow disruption (e.g., water diversion that result in entrainment and in-channel barriers or tidal gates) for the period February 1 to August 31.

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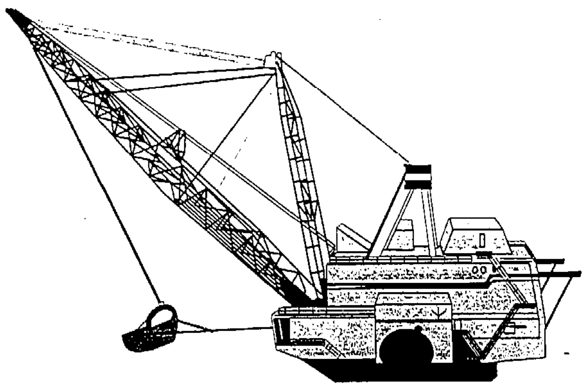
Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program Draft EIS/EIR Technical Appendix. July 2000.

◆ Dredging and Sediment Disposal



Introduction

Dredging and sediment disposal serves a number of purposes in the Bay-Delta. Most dredging is done to maintain or deepen navigation channels, harbors, and marinas. Dredging is also required to maintain or increase flood control and water conveyance capacity and to obtain material for levee maintenance and repair. This maintenance dredging activity is required because sediments transported to the Delta tend to accumulate in deep channels and backwater areas.

Stressor Description

Approximately 2-5 million cubic yards of bottom material must be dredged from the Bay-Delta each year to maintain adequate depth for navigation channels, harbors, and marinas and to maintain flood control and water conveyance capacity. As harbors and channels are deepened to accommodate larger cargo ships, this amount is expected to increase to more than six million cubic yards per year over the next 50 years.

Dredging maintains the Stockton ship channel through the Delta along the San Joaquin River, the Sacramento deepwater ship channel, and the storage capacity in Clifton Court Forebay. Without this maintenance dredging activity, the channels and harbors would become too shallow to accommodate container ships and other heavy vessels. Lack of dredging would also increase the frequency and severity of Delta island flooding. Conveyance of freshwater from the Sacramento River to the southern Delta pumping facilities would also become less efficient.

Dredging and the disposal of dredged material are potentially harmful to the natural productivity of the Bay-Delta ecosystem. The harmful effects of dredging could be a result of the destruction or disruption of benthic communities, turbidity (muddy water) plumes, and release of organics and contaminants from sediments.

Dredge material disposal poses potential environmental problems, particularly when it contains polychlorinated biphenyls (PCBs), elevated concentrations of trace metals, or other potentially harmful constituents. The major effects of increased suspended sediment concentrations (turbidity) at sediment disposal sites are probably on fish behavior, feeding patterns, foraging efficiency, modified prey response, and habitat choice (San Francisco Estuary Project 1993).

Historically, the main disposal sites for dredged material were in the Bay near Alcatraz Island, and offshore in an area that is now within the Gulf of the Farallones National Marine Sanctuary. The Alcatraz disposal site is no longer suitable because it has become a navigation hazard. Disposal is banned in the marine sanctuary. Efforts to identify, evaluate, and prioritize alternative disposal sites are currently underway as part of the LTMS.

Dredging material is needed for agricultural stability and for use in ecosystem restoration. Fill is needed to construct setback levees, reinforce existing levees, and restore wetlands and riparian areas, channel island habitats, and other critical areas. The need for fill will be particularly acute in the lowest-lying Delta islands, some of which are 20 feet or more below sea level. One alternative for restoration efforts in subsided areas would require using fill to stop the oxidation of organic matter in peat soils. Fill material may also be required on islands that are used for continuing agricultural production.

VISION

The vision for dredging and sediment disposal in the Bay-Delta is to maintain adequate channel depth for navigation, flood control, and water conveyance while reducing the adverse effects of dredging activities on the Bay-Delta ecosystem.

Dredged material disposal would be environmentally sound and the use of nontoxic dredged material would be promoted as a resource for restoring tidal wetlands and other habitats, reversing Delta island subsidence, and improving dikes and levees.

The ERPP supports the interagency long-term management strategy (LTMS) for dredged materials in the San Francisco Bay and recommends that approximately half of the dredged material from the Bay-Delta be used to restore habitats and strengthen levees. Because one million cubic yards are equivalent to about 620 acre-feet (af), approximately one square mile (640 acres) 3 feet deep can be restored each year. The amount of high-potential tidal wetland restoration sites within the Bay is more than 10,000 acres.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

ERPP supports and seeks to extend the regional approach to dredging and sediment disposal decision making embodied in the LTMS developed by the U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, the San Francisco Bay Regional Water Quality Control Board (RWQCB), the Central Valley RWQCB, and the San Francisco Bay Conservation and Development Commission with the involvement of other agencies and stakeholder groups.

One of the objectives of the LTMS is to promote the reuse of dredged materials whenever it can be shown that there is a need for the material and placement can be done in an environmentally acceptable manner. Restoring tidal wetlands, constructing setback levees, restoring riparian areas and channel islands, and other efforts needed to restore Bay-Delta foodweb productivity and the abundance of fish, waterfowl, and wildlife populations will require fill material. Therefore, there is a great opportunity for linkage between ERPP efforts and managing dredging in the Bay-Delta to the mutual benefit of the ecosystem and the industries dependent on safe and efficient navigation in the Bay-Delta.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

The adverse effects of dredging and the disposal of dredge materials can be adjusted to contribute to restoring ecological health of the Bay-Delta. Dredge materials can be used to recreate shallow water habitats throughout the Delta. This will increase the acreage of this type of habitat and support aquatic and plant species dependent on shallow water habitat.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

The Strategic Objective for dredging and sediment disposal is Rehabilitate natural processes to create and maintain complex channel morphology, in-channel islands, and shallow water habitat in the Delta and Suisun Marsh.

LONG-TERM OBJECTIVE: To link dredging and spoil disposal with environmental restoration, reversal of subsidence, and levee maintenance.

SHORT-TERM OBJECTIVE: Reduce adverse environmental impacts and further demonstrate the beneficial reuse of dredge materials.

RATIONALE: Dredging is a necessary activity that is conducted to maintain shipping channels and channel capacity during flood flow events. Dredging can be conducted in an environmentally benign manner and clean, uncontaminated dredge spoils can be used for many uses including levee reconstruction, wetland restoration, reversal of subsidence, and the creation of shallow water habitats.

STAGE 1 EXPECTATIONS: Pilot programs that demonstrate the beneficial reuse of dredge materials for ecological purposes will have been implemented by creating wetland and shallow water habitats in the Delta and Bay.

RESTORATION ACTIONS

The general target for dredging and dredge disposal is reduce the loss and degradation of habitat and to contribute sediments for the recreation of shallow water habitats.

The following actions would help to achieve this vision:

- Coordinate all actions closely with federal, State, and local agencies charged with regulating dredging activities in the Bay-Delta.
- Reduce the amount of contaminants flowing into the Bay-Delta and subsequently absorbed by Bay-Delta sediments.
- Identify alternative dredged material disposal sites including upland and ocean sites, to ensure that disposal activities are flexible and avoid undue reliance on a small number of sites.
- Maximize the reuse of dredged materials for habitat restoration and other beneficial uses and minimize the amount of disposed material that is subject to resuspension and subsequent redredging.
- Support continued research on sediment transport and deposition, sediment quality and toxicity testing, the environmental effects of suspended sediment and contaminants, and the beneficial reuse of dredged materials so that dredging and sediment disposal management will continue to improve.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied and historic Central Valley habitats used by listed species with other federal, state, and local programs (e.g., the SB 1086 Program, the Anadromous Fish Restoration Program, U.S. Fish and Wildlife Service recovery plans, and the Corps' Sacramento and San Joaquin River Basins Comprehensive Study) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.
- Protect the Sacramento and San Joaquin river and tributary channels from physical disturbance (e.g., sand and gravel mining, dredging, and levee or bank protection and maintenance) and flow disruption (e.g., water diversion that result in entrainment and in-channel barriers or tidal gates) for the period February 1 to August 31.
- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program and the recovery plan for the native fishes of the Sacramento/San Joaquin Delta.
- Implement management measures identified in the proposed recovery plan for the Sacramento River winter-run chinook salmon.

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◆ GRAVEL MINING

INTRODUCTION

The natural sediment supply of Central Valley rivers and streams is composed of mineral and organic fines, sands, gravel, cobble, and woody debris (e.g., tree branches and root wads), sediments that naturally enter, transport and erode through the system. Sediment is one of the natural building blocks of the ecosystem on which many other ecological processes, functions, habitats and species depend. Gravel, for example, is important for maintaining spawning habitat of salmon and steelhead and supports many invertebrates on which young fish prey. Finer sediments and fluvial (flowing water) processes create conditions necessary to establish new riparian forests and wetlands.

Human activities have had a significant adverse effect on natural sediment processes in the Bay-Delta watershed. One of the more prominent adverse activities is the removal of sand and gravel from active stream channels. Both abandoned and active mining sites exist on virtually every stream or streamside alluvial deposit throughout the ERPP study area (Reynolds et al. 1993).

Sand and gravel mining is a valued commercial activity, but it has impaired sediment transport, gravel recruitment, and stream channel meander processes. Instream gravel extraction damages riparian vegetation, movement of groundwater, water quality, and fish and wildlife populations. In some areas, abandoned gravel pits now harbor predatory fish, serve as heat sinks that increase the ambient water temperature, or capture sediment naturally moving downstream.

STRESSOR DESCRIPTION

Development throughout the Central Valley has increased the demand for aggregate used in construction. Records of the Department of Conservation, Office of Mine Reporting and Reclamation Compliance, show that 1.53 million tons of aggregate were mined in Tehama and Shasta Counties in 1992. In Shasta County, more than half of the aggregate mined came from quarries, and was not alluvial gravel. It is also notable that in 1992, there was only one in-stream mining operation is Shasta County. County and California Department of Fish and Game permits show that up to four million tons could have been mined in the area in 1994, although the actual mined quantity may have been substantially less.

Wide-scale gravel extraction has damaged bridges, siphons, and other river-crossing structures by aggravating degradation and undermining foundations. In Glenn County, for example, the State Route 32 bridge over Stony Creek has been repaired three times at a cost of nearly $2 million. In Tehama County, the Corning Canal siphon is being exposed as the bed degrades, and repairs will cost several million dollars. The North Main Street bridge over Dibble Creek in Red Bluff has been repaired several times at a cost of more than $100,000, and the California Department of Transportation (CalTrans) has replaced the Interstate 5 bridge over Cottonwood Creek in Shasta County.

Riparian communities are affected by mining in several ways. The most obvious adverse effect is the direct removal or destruction of riparian vegetation by construction of access roads, mined areas, and storage areas. Riparian vegetation can also be lost by degradation and streambank undermining. In addition, degradation and groundwater table reductions destroy shallow-rooted riparian forest for large areas surrounding gravel mines.

Fish are directly affected by gravel removal. Anadromous fish use gravel for spawning. Salmon generally spawn in riffles with water velocities between one and 3 feet per second at a depth of between 0.5 and 3 feet. Mining activities may change riffle velocity and depth or deplete spawning-sized gravel. The Sacramento River and many of the tributaries in the Redding area have been depleted of gravel from a combination of mining and lack of gravel moving downstream from the area above Lake Shasta. In some places, the remaining substrate is too coarse for salmon spawning; in other places, bedrock is exposed over large sections of the stream.

Channel braiding caused by uniform grading during bar excavation can create conditions unsuitable for fish. Higher water temperatures are caused by lower velocities, shallower waters, and reduced vegetation cover of a braided channel. Many fish cannot survive or spawn in higher-than-normal temperatures. These effects may be avoided by maintaining a narrow and deep low-flow channel through a gravel mining area.

Instream gravel mining involves the direct removal of sand, gravel, and cobble from the channel and active floodplain of a stream. Instream mining degrades or eliminates river ecosystem functions, processes, and habitats in the following ways:

- Instream mining homogenizes the geomorphology (shape) of the river channel and its floodplain. Mining removes complex bed forms and elevated floodplains. Channels are typically widened and deepened at mining sites, creating an environment that stops downstream gravel transport. Gravel depletion can accelerate erosion and depletion of several miles of downstream gravel bars. The river will adjust to the reduced bedload by eroding valuable instream bar deposits. Therefore, instream mining causes both direct and indirect downstream loss of gravel and gravel bars.

- Historic extraction rates often exceeded the average annual yield of gravel from upstream areas. This condition further halts the downstream transport of gravel and often triggers channel incision from the upstream and downstream migration of nick points in the bed elevation as the river compensates for the loss of bedload. Instream mining may cause an increase in the downstream sediment load from fissure sediments dislodged by surface disturbance from mining or channel adjustment. Downstream sedimentation may bury spawning beds in sand and silt or suffocate fish eggs in spawning gravels. Most conditional use permits for instream mining issued in California in the last 10 to 15 years do not permit extraction rates to exceed annual yield.

- Instream mining of active channel bars and deep channel deposits is particularly disruptive to the sediment budget of alluvial streams below large dams. This is especially true where there are no major tributaries downstream of the dam to supply another source of gravel and sediment. An example of this condition is the lower American River, where instream and floodplain mining has ceased but where the only significant source of gravel and sediment is from bank and channel erosion below Nimbus Dam. Channel armoring has occurred where bars in the salmon spawning reach are primarily composed of cobbles that resist bed transport at the most common flows. The lower American River and the lower Yuba River are also depleted of fine sediment on bar deposits. There is little support for recruitment of cottonwood seedlings and saplings because these trees cannot germinate or survive in the coarse substrate during summer low-flow conditions.

- Historically, mining removed riparian vegetation, instream woody debris, and spawning redds. All vegetative cover and fluvial landforms were removed to gain access to the mining site and to clean and sort gravel for commercial use. These habitats may not have been replaced until instream mining ceases. Presently, conditional use permits issued in California usually require protection and non-disturbance of some or all riparian vegetation. In addition, many permits require concurrent reclamation, so that soil and vegetation is replaced as the mining progresses from one area to the next.

- Deep pit mines excavated in the channel and active floodplain may result in "pit capture." Deep pit mines, such as those prevalent in the tributaries to the San Joaquin River, are often separated by a wall of unexcavated river alluvium. These walls are easily eroded or overtopped by high flows. When this occurs, the river may avulse (move suddenly) from the natural channel into and through the pit, where most gravel bedload will then be captured.

When high flows recede, fish will be trapped in the instream "lakes" that are formed. Juvenile salmonids trapped in these lakes are subject to predation and high water temperatures.

- Disturbance from instream mines often leads to the invasion of undesirable non-native plants. Streams with instream mining are often sites with high rates of colonization by invasive non-native plants, such as tamarisk, eucalyptus, giant reed, and pepperweed. These species spread through displaced stem and root fragments or by prolific seed dispersal. For example, channel grading for levee construction and mining on Stony Creek, along with bank erosion, causes giant reed plants to be transported downstream and into the Sacramento River corridor. Once in the corridor, they colonize natural bars and compete with native trees and shrubs. Freshly disturbed and exposed areas at mines also offer prime invasion sites for weedy, opportunistic plant species. This situation is partially remedied by present requirements which include reclamation plans that include comprehensive revegetation with native species and eradication of non-native invasive species.

ISSUES AND OPPORTUNITIES

CHANNEL DYNAMICS, SEDIMENT TRANSPORT, AND RIPARIAN VEGETATION: There is growing recognition that dynamic river channels, free to overflow onto floodplains and migrate within a meander zone, provide the best riverine habitats. The dynamic processes of flow, sediment transport, channel erosion and deposition, periodic inundation of floodplains, establishment of riparian vegetation after floods, and ecological succession create and maintain the natural channel and bank conditions favorable to salmon and other important species. These processes also provide important inputs of food and submerged woody substrates to the channel. The most sustainable approach to restoring freshwater aquatic and riparian habitats is by restoring dynamic channel processes; however, restoration of natural channel processes is now hampered by the presence of levees and bank protection along many miles of rivers. Below reservoirs, the reductions in high flows, natural seasonal flow variability, and supply of sand and gravel have further exacerbated the constraining effect on rivers with levees and rock banks. It is therefore a priority to identify which parts of the system still have (or can have) adequate flows to inundate floodplains and sufficient energy to erode and deposit, and to identify floodplain and meander zone areas for acquisition or easements to permit natural flooding and channel migration. Sediment deficits from in-channel gravel mining should also be identified and the feasibility or efficacy of augmenting the supply of sand and gravel in reaches below dams should be evaluated (Strategic Plan).

OPPORTUNITIES: Mimic natural flows of sediment and large woody debris. Dams disrupt the continuity of sediment and organic-debris transport through rivers, with consequent loss of habitat, and commonly, river incision, downstream. In some cases, such as Englebright Dam on the Yuba River, the feasibility of dam removal should be evaluated as a sustainable solution to reestablishing continuity of sediment and debris transport, as well as opening access to important spawning and rearing areas. Most dams, however, cannot be removed, so methods must be sought to reestablish continuity of sediment and wood transport with the dam in place. Coarse sediment can be artificially added below dams to at least partially mitigate for sediment trapping by the dam and ameliorate the impacts of sediment-starved flows. This approach has been successfully used in Europe, using sediment from natural (landslide) and artificial sources (injected from barges). On the River Rhine, enough gravel and sand are added below the lowest dam to satisfy the present sediment transport capacity of the Rhine to prevent further incision of the bed (an average of over 200,000 cubic yards annually). On the Sacramento River, gravels have been added at a rate much below the river's transport capacity so they are vulnerable to washout at high flows. A more sustainable approach would be to add gravel (and sand) on a regular basis and at a much larger scale to better mimic natural sediment loads and therefore provide the sediment from which the river would naturally create and maintain spawning riffles. This latter approach requires a large commitment of resources and should be undertaken only in rivers where other factors (e.g., temperature regime) are favorable (or can be made favorable) for recovery of species (such as the upper Sacramento). Such opportunities will be more economical where sources of dredger tailings or reservoir Delta deposits are available nearby.

While recognizing the navigation and flood safety issues associated with large woody debris in rivers, the importance of this debris to the foodweb and structural habitat for fish should not be overlooked. There is an opportunity to investigate ways by which to pass debris safely through dams and bridges. This may require replacing some existing bridges with those less prone to trapping woody debris.

Identify and conserve remaining unregulated rivers and streams and take actions to restore natural processes of sediment and large woody debris flux, overbank flooding, and unimpaired channel migration. Most rivers in the Central Valley are regulated by large reservoirs and therefore require considerable investment to recreate the natural processes needed to sustain true ecosystem restoration; however, a few large unregulated rivers still exist, such as the Cosumnes River and Cottonwood Creek. Lowland alluvial rivers and streams with relatively intact natural hydrology should be identified and made a high priority for acquisition of conservation and flooding easements, setting back of levees, and other restoration actions because such actions on these rivers are likely to yield high returns in restoration of natural processes and habitats and, ultimately, fish populations.

Undertake fluviogeomorphic-ecological studies of each river before making large investments in restoration projects. River ecosystem health depends not only on the flow of water, but on the flow of sediment, nutrients, and coarse woody debris and on interactions between channels and riparian vegetation, variability in flow regime, and dynamic channel changes. It is only through interdisciplinary, watershed, and historical scale studies that the constraints and opportunities particular to each river can be understood. For example, it was only after a fluviogeomorphic study of Deer Creek that the impact of flood control actions on aquatic and riparian habitat was recognized, a recognition that has lead to a proposal for an alternative flood management approach designed to permit natural river processes to restore habitats along Lower Deer Creek.

VISION

The vision for gravel mining is to improve gravel transport and cleansing by reducing the adverse effects of instream gravel mining.

Achieving this vision would help to maintain or restore flood, floodplain, and streamflow processes that govern gravel supply to improve fish spawning and floodplain habitats.

Opportunities to achieve the vision for gravel mining include reducing or eliminating instream gravel extraction by relocating gravel mining operations to alluvial deposits outside active stream channels and riparian zones and introducing gravel in deficient areas in streams until natural processes are restored to a level that will provide sufficient quantities. The Ecosystem Restoration Program Plan (ERPP) supports channel design or levee construction projects consistent with restoring floodplains to ameliorate this problem. In certain situation, gravel mining is used as a surrogate for adequate flood control to prevent flooding, for bank protection, and to protect structures.

One strategy to achieve this vision is to identify alternative sources of gravel for fishery restoration and other uses instead of extracting gravel for these purposes from active stream channels. Potential impacts and mitigations for in-stream mining, gravel bar skimming and terrace gravel operations should be evaluated on a case-by-case basis, and could be permitted, provided that an acceptable stream management and reclamation plan is prepared, funded, and implemented. However, portland cement concrete grade aggregates are found only in in-stream and terrace deposits. Materials from other sources may not be as suitable as in-stream aggregates.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Programs sponsored by other agencies that would also help to achieve the ERPP vision for gravel mining and recruitment include:

- county-sponsored instream mining and reclamation ordinances and river and stream management plans, such as new gravel and stream management plans approved in Butte and Yolo Counties;

- the State Department of Conservation's reclamation planning assistance programs under the Surface Mining and Reclamation Act;
- Anadromous Fish Restoration Program gravel replenishment programs and plans and small dam removal and/or fish ladder rehabilitation projects (USFWS 1997);
- the San Joaquin River Parkway plan; and
- efforts by the State Department of Conservation and counties to identify alternative sources of commercial sand and gravel in reservoir deltas, floodplain terrace deposits, old dredger mining cobble deposits, and hardrock sites.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Gravel and sand extraction activities have the potential to adversely effect several important ecological processes, habitats, and the dependent species. Ecological processes include natural sediment supply and stream channel meander. Riparian and riverine aquatic habitat is the most common habitat that is adversely effected by gravel mining. Many fish, wildlife, and plant species are dependent on gravel beds, sediment, and riparian corridors. These are reduced by gravel mining. However, careful planning and mitigation of gravel operations can eliminate adverse impacts.

OBJECTIVE, TARGETS, ACTIONS, AND MEASURES

> The Strategic Objective is to restore coarse sediment supplies to sediment-starved rivers downstream of reservoirs to support the restoration and maintenance of functional natural riverine, riparian, and floodplain habitats.

LONG-TERM OBJECTIVE: Implement a comprehensive sediment management plan for the Bay-Delta system that will minimize problems of reservoir sedimentation and sediment starvation, shift aggregate extraction from rivers to alternate sources, and restore continuity of sediment transport through the system to the extent feasible.

SHORT-TERM OBJECTIVE: Develop methods and procedures to end gravel deficits below dams and mining operations; prioritize for correction existing streams with major deficit problems and initiate action on at least 10 streams.

RATIONALE: One of the major negative effects of dams is the capture of coarse sediments that naturally would pass on to downstream areas. As a result, the downstream reaches can become sediment starved, producing "armoring" of streambeds in many (but not all) rivers to the point where they provide greatly reduced habitat for fish and aquatic organisms and are largely unsuitable for spawning salmon and other anadromous fish. This objective can be accomplished by a wide variety of means, but most obviously through artificial importation of gravel and sand. Other possible actions include: (1) explore the feasibility of passing sediment through small reservoirs; (2) remove nonessential or low-value dams; (3) eliminate instream gravel mining on channels downstream of reservoirs, and limit extraction on unregulated channels to 50% of estimated bedload supply or less (or to levels determined not to negatively impact fish and other ecological resources); (4) develop incentives to discourage mining of gravel from river channels and adjacent floodplain sites; and (5) develop programs for comprehensive sediment management in each watershed, accounting for sediment trapped by reservoirs, availability of sediment from tributaries down stream of reservoirs, loss of reservoir capacity, release of sediment-starved water downstream, channel incision and related effects, and the need for sources of construction aggregate.

STAGE 1 EXPECTATIONS: Sediment-starved channels in the Bay-Delta system will have been identified; strategies to mitigate sediment starvation, such as shifting mining of gravel from river channels to alternate sources, adding gravel below dams, and removing nonessential dams will have been developed; demonstration projects will have been implemented (and monitored) to mitigate sediment starvation in at least six rivers.

Restoration Actions

The general target for gravel mining is work with local counties and the aggregate resource industry to relocate gravel extraction operations to areas outside the active stream channel.

Three actions to reducing the adverse effects of gravel mining include the following:

- Promote alternative gravel sources. ERPP recommends providing education and other incentives to encourage counties and mining companies to seek new off-channel sources of aggregates, including high terraces outside the active floodplain, recycled concrete, crushed cobbles from old abandoned dredge spoils, and deep pit mines away from river migration corridors. New permits for these aggregate sources can be issued in exchange for phasing out instream mines.

- Limit the extent of disturbance at instream mines. If alternative sources of aggregate are not a viable short-term solution, permits should require an undisturbed corridor of riparian vegetation and natural bar deposits adjacent to existing mines. In addition, extraction rates should be limited to the estimated yield from upstream each year. This rate will vary annually and must be verified by aerial topographic analysis or field surveys at permanent transects.

- Prevent or reduce the effects of pit capture. Deep pits should be adequately separated from the channel and measures should be taken to ensure that bank material and vegetation will resist channel migration in the direction of the pits. Alternatively, permits should require that inchannel pits be filled with overburden to the elevation of the channelbed.

MSCS Conservation Measures

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Coordinate protection, enhancement, and restoration of occupied and historic Central Valley habitats used by listed species with other federal, state, and local programs (e.g., the SB 1086 Program, the Anadromous Fish Restoration Program, U.S. Fish and Wildlife Service recovery plans, and the Corps' Sacramento and San Joaquin River Basins Comprehensive Study) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.

- Protect the Sacramento and San Joaquin river and tributary channels from physical disturbance (e.g., sand and gravel mining, dredging, and levee or bank protection and maintenance) and flow disruption (e.g., water diversion that result in entrainment and in-channel barriers or tidal gates) for the period February 1 to August 31.

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